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A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

EDITED BY A. S. RUSSELL, M.C., D.Sc.

JAN 14 1921

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THE CUP-BEARER OF KNOSSOS

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JOHN MURRAY, 50A ALBEMARLE STREET, LONDON, W.1.

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Edited by EDWARD LIVEING, B.A.
Scientific Adviser: A. S. RUSSELL, D.Sc.

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Editorial Notes

A HAPPY period spent recently in bed gave me an opportunity of rereading some of Dickens, and led me to the fascinating and interesting problem of Edwin Drood. This problem is an excellent one to study during an illness, not only because it takes one's mind away from the happenings of to-day, but also because its solution does not involve anything that is vital. However the various problems of the story may be solved, no one—not even the author of the story—is one penny the worse. The problem of Edwin Drood exists, of course, because this last novel of Dickens has barely half been told, and because Dickens built up his stories according to a system on which conjectures may be based regarding the possible development and end of the story.

* * * * *

The problems in the story are these:

(1) Was Edwin Drood murdered? Is so, how, by whom, and where was his body hidden?

(2) Who was Datchery, the stranger who appeared in Cloisterham after Drood's disappearance?

(3) Who was the old opium woman called the Princess Puffer, and why did she pursue Jasper? The last of these is not of great interest, and as the materials available for its solution are scanty, it has been dropped by most people. Not so, however, the others.

It was Mr. R. A. Proctor, the astronomer, who started the serious discussion on these problems. He put forward a view that Drood was not murdered, but rescued by Durdles from the bed of quicklime, and that he appeared later in the story disguised as Datchery. Among the chief of those who have contributed to the discussion have been Mr. Cuming Walters, Dr. M. R. James, Prof. Henry Jackson, and Sir W. Robertson Nicoll. The general opinion now is that Jasper would have murdered Drood by strangling him with his neckerchief and casting the body into lime. The gold ring on Drood's hand would have escaped decomposition, and would ultimately reveal the murderer. This was the little fact that the story-book murderer, for all his cleverness, was going to overlook. Sir W. R. Nicoll, whose book[1] on the subject is perhaps the best, accepts this view, and the latest book,[2] that by Mr. Carden (published at the end of 1920), concurs.

* * * * *

The question, "Who was Datchery?" is a much harder one. If one assumes, as nearly all students of the problem do, that Datchery is someone in disguise and someone who has already appeared in the book, the choice narrows itself to Bazzard, the clerk of Old Grewgious; Tartar, the seafaring man whose job was to look after Neville; and curiously enough Helena Landless. Bazzard seems the obvious solution to any reader who forgets that an author is nearly always cleverer than all but the acutest of his readers. Tartar is another solution; it has been ably advocated by Mr. Gadd, and Mr. Carden adopts this solution in his book. The majority, and notably Mr. Cuming Walters, and later Sir W. R. Nicoll, believe that Datchery was really Helena Landless cleverly disguised. She had the necessary qualifications. Her whole heart was in the affair for which the disguise was necessary. The fact that Datchery concealed his hands on nearly every occasion suggests that he was a woman. It is a pity that we shall never know the truth.

[1] *The Problem of Edwin Drood.* A Study in the Methods of Dickens. (Hodder & Stoughton, 4*s.* 6*d.*)

[2] *The Murder of Edwin Drood.* By Percy T. Carden. (Palmer, 6*s.* net.)

Surnames and the Chronology of the English Vocabulary

By Professor Ernest Weekley and Miss Dorothy D. Pilkington, M.A.

To students of the English language the date of first appearance of such words as are not already recorded in Anglo-Saxon is a matter of considerable interest. The great authority in this matter of chronology is, of course, the New English Dictionary.[1] But this monumental work has made hardly any use of one of the most valuable sources of information, viz. the surnames of our ancestors recorded in the Government Rolls and in innumerable local documents such as Abbey cartularies, Borough records, Manor Court rolls, etc., of which great numbers have been published by various antiquarian societies. Surnames are now felt to be proper nouns which have no place in a dictionary; but this only applies really to patronymics (Edwards, Johnson, Dicks, etc.), or to those taken from the names of towns and villages (Bedford, Chichester, Bingham, Woodley, etc.). All other surnames originated as descriptions (Arrowsmith, Baker, Good, Bullock, Partridge, Armstrong, Sheepshanks, Shakespear, Doolittle, Truelove, etc.) or addresses (Field, Wood, Athill, Bytheway, etc.), and are formed from the everyday colloquial language. If, then, we find the name of Alan le arwesmyth in the Close Rolls for 1288–96, we may conclude that the first N.E.D. record for *c.* 1400 must be at least one century, and probably two or three centuries, too late, as the compound would not be likely to be used as a description or means of identification unless it were a well-understood word of long standing. It is sufficiently clear that any word in general use as a surname must have had a pretty long previous existence in the language.

In this article only one group of surnames is considered, viz. the interesting class of nicknames of compound form. Such names may be (1) descriptive of occupation, e.g. Bridgman, Cartwright; (2) names of wares which the bearer made or sold, e.g. Horsnail, Whitbread; (3) verbal phrases descriptive of trade, habit, habitual gesture, etc., e.g. Boughtflower (= bolt, i.e. sift, flour), Wagstaff; (4) physical nicknames, e.g. Broadhead, Lightfoot; (5) descriptive of dress or equipment, e.g. Curthose, Longstaff; (6) animal nicknames, e.g. Duncalf, Woodcock; (7) descriptive of characters, e.g. Gentleman, Merryweather; (8) from abstract qualities, e.g. Fairservice, Truelove. There are also a great many miscellaneous compounds which do not fit into this, necessarily rather rough, classification, such as names derived from the vegetable world, e.g. Peascod, Sweetapple, from coins and money, e.g. Halpenny, Hallmark (for half-mark), and from oaths and exclamations, e.g. Pardew (par Dieu), Godbehere. How such names were acquired is not a question which can be dealt with here. Those which survive as existing surnames are only a very small proportion, but there are enough of them to give some idea of the extraordinary and fantastic character of Middle English nomenclature. On the other hand, a very large number of compounds which now exist as common nouns only are found as mediæval nicknames, and very often, as we shall see, at dates long anterior to the earliest records established by the N.E.D.

I will now quote a few examples from the various classes of compounds, giving the date at which each is found as a surname compared with the date of the first record given by the N.E.D. of the same word as a common noun. The material I have before me[2] contains a list of nearly 250 examples which antedate the N.E.D. by one century at least, and sometimes by more than four centuries, besides some thousands of compounds of which dictionaries show no record. It should be premised that the great mass of English surnames were the creation of the twelfth and thirteenth centuries (the Anglo-Saxon had usually a single name), and began to become hereditary and fixed from the fourteenth century onward. Hence, as a general rule, we may assume that any word now well established as a surname must have been current in English not very long after the Conquest. This may be illustrated by such a name as Crabtree, common in the West Riding of Yorkshire. The N.E.D. records *crab* (apple) *c.* 1420, and *crabtree c.* 1425; but the existence of the latter as a mediæval surname suggests that both the compound and the simplex must have been familiar words at least a century earlier. This name is also an example of the impossibility of "explaining" surnames. Did the first Crabtree obtain his name from the tree near which he lived (cf. Ash, Thorne, or Nash, i.e. *atten ash*, Noakes, i.e. *atten oaks*), from his "vinegar aspect" (cf. Sweetapple), or from habitually carrying a crabtree staff (cf. Hardstaff)? It is impossible to say which, if any, of these explanations is the true one. The same applies to many of the names dealt with in

[1] Referred to in the article as N.E.D. A short account of the New English Dictionary appeared in DISCOVERY for July 1920, p. 196.

[2] This material consists of a thesis for which Miss Dorothy Pilkington was awarded in 1920 the M.A. degree of the University of London. The character of the investigation was suggested by me, and I also indicated to Miss Pilkington the chief sources of which she could make use. The results she has obtained seem to me of considerable value for the historical study of our language.

this article. What appears to be an occupative surname may have been originally a nickname given for reasons now unknown, and mediæval sobriquets were no doubt often ironical, so that Makepeace may have been cantankerous, Drinkwater a wine-bibber, Snowball a swarthy man, and Fairweather a grouser. As the N.E.D. has not yet got beyond V, no comparison is possible for the rather numerous compound names in W. For these Stratmann and Bradley's Middle English Dictionary may be consulted. This contains, for instance, no record of *wainwright*, though, judging from its frequent occurrence as a surname, it must have been current English by *c.* 1300 at the latest. In fact it is well attested as a surname from about that date.

The following are some of the most striking examples of occupative names taken from Miss Pilkington's lists:

N.E.D. Record.		Surname Record.
ale-brewer	*c.*1510	Cristin le alebrewere (City Letter-books, 1307–27).
anchor-smith	1662	Benedict ankersmith (Norwich Records, 1355)
bell-founder	1530	Michael the bellfounder (Close Rolls, 1318–23).
blacksmith[1]	1483	William blakesmyth (Patent Rolls, 1266–72).
boatman	1513	Gervase the boteman (Patent Rolls, 1313–17).
candle-maker	1611	Theophilus the kandilmaker (Patent Rolls, 1317–21).
cellarman	1658	Walter le celeresman (Coram Rege Rolls, 1297).
charwoman	1596	Alice charwoman (Nottingham Records, 1379).
cheesemonger	*c.*1510	Baldwin le chesemangere (Pipe Rolls, 1185–6).
coxswain	1463	John cokeswayne (Patent Rolls, 1327–30).
cornmonger	*c.* 1515	Peter le cormangere (Pipe Rolls, 1176–7).
cowkeeper	1680	David le cowkeeper (Vale Royal Abbey, 1330).
ferryman	1464	Richard le feriman (Lanc. Assize Rolls, 1246–7).
fisherman	1526	Silvester the fisherman (Close Rolls, 1327–30).
fishmonger	1464	Lawrence le fysshmongere (Close Rolls, 1307–13).
foxhunter	1692	William le foxhunte (Patent Rolls, 1258–66).
goldbeater	1415	Robert le goldbeter (Hundred Rolls, 1273).
horse-merchant	1711	Theobald the horsemerchant (Close Rolls, 1272–9).
hunt(s)man	1567	Walter hunteman (Hundred Rolls, 1273).
knifesmith	1738	Adam knyfesmith (Lanc. Assize Rolls, 1285).
shearsmith	1623–4	Geoffrey sheresmyth (Freemen of York, 1391).
stone-hewer	1579–80	John the stoneheware (Gloucester Records, *c.* 1230).

[1] This may refer to the smith's complexion (cf. the name Brownsmith).

In addition to the above selection may be mentioned a large number of compounds of *-man* (inkman, mailman, leatherman, oysterman, etc)., *-monger* (buttermonger, feathermonger, flaxmonger, horsemonger, etc.), *-wright* (glasswright, basketwright, kitwright, tilewright, etc.), mostly recorded as surnames some centuries earlier than the N.E.D. There are also some archaic titles of interest to the historian and the antiquary. The N.E.D. defines the obsolete *borsholder* (recorded 1536) as "the chief of a tithing or frankpledge; afterwards a parish officer identical in functions with the Petty Constable." Thomas le borewesaldre is in the Charter Rolls for 1257–1300. *Frankpledge* is found in Anglo-French form in Britton (1292). The first English record is 1495, and the sense of "one of the mutually responsible members of a tithing" is not found by the N.E.D. till 1502. But Robert le francpledge occurs in 1237 in Archbishop Gray's Register. Even *hayward*, the parish official responsible for fences, etc., recorded by the N.E.D. from the Ancren Riwle (early thirteenth century), is taken a little further back by Miss Pilkington, who has found Ricardus heiward in the Pipe Rolls for 1165–6. Occasionally a name of this type points to the earlier existence of a simplex, e.g. the name of Robert le mittenmaker in Norwich Records, 1288, shows that *mitten* must be considerably older than the N.E.D. record, *c.* 1386.

Surnames taken from names of commodities are not necessarily of occupative origin, but there are strong reasons for believing that this is often the case, e.g. that Hogsflesh was the nickname of a pork-butcher, Horsnail of a farrier, Whitbread of a baker, etc. Examples of compounds of this kind are—

N.E.D. Record.		Surname Record.
barley bread	*c.* 1320	Josce barlibred (Pipe Rolls, 1184–5).
blanc-mange	1377	Stephen blangmong (Hundred Rolls, 1273).
butter-kit (= cask)	1567	Robert buktreyde (*ibid.*).
bread-and-cheese	1589	Robert chesandbred (Patent Rolls, 1330–4).
codfish	1565–73	Thomas cotfich (Hundred Rolls, 1273).
hard-fish (= dried)	1808	Richard hardfyssh (Feudal Aids, 1401–2).
honeypot	1483	John hunypot (Patent Rolls, 1313–17).
horse-nail	1598	William horsnail (Close Rolls, 1234–7).
rye-bread	1597	Adam rybred (Charter Rolls, 1300–26).
small-ware	1617	Robert smalware (Pipe Rolls, 1184–5).

The most picturesque type of compound surname is that formed from a verb accompanied by a noun or an adverb, e.g. Shake-spear, Go-lightly. Here the comparison with dictionary dates can only be made occasionally, as few of these compounds appear to have got recorded as common nouns, though they swarm in the Middle Ages as surnames, not only in England, but

in Continental countries. The list before me includes about a thousand of this class. Here are a few which are registered by the N.E.D. as occurring in (mostly archaic) language :

N.E.D. Record.		Surname Record.
drinkwater	1641	John drinkwater (Hundred Rolls, 1273).
lickdish (= parasite)	1440	Leofric likedich (Ramsey Cartulary, 1114–19).
makepeace	1516	Gregory makepais (Leicester Records, 1219).
picklock	1553	Thomas pyclok (Patent Rolls, 1338–40).
rattlebag	1728	John ratellebagge (Hundred Rolls, 1273).
scattergood (= prodigal)	1577	Robert scatergod (Cockersand Cartulary, 1200–26).
sparegood (= miser)	1611	Walter sparegod (Hundred Rolls, 1273).
spillcause (= marplot)	1566	Alexander spillecause (*ibid.*).

Sometimes a surname of this type throws light on the antiquity of a verb, e.g. the N.E.D. does not record the verb *to drain* till 1538, but Simon draneland lived in the Cambridgeshire fens in 1273 (Hundred Rolls). The colloquial verb *to lump* (like it or lump it) is recorded for 1577, but Matilda lumppejoye, apparently the opposite of the existing Lovejoy, is in the Patent Rolls for 1307–13. The N.E.D. has (1586) the odd compound *break-dance* in the sense of turbulent. William brekedaunce is in the Patent Rolls for 1330–4. The phrase "to turn a penny" is first recorded for 1546, but Matilda tornepeni is in the Hundred Rolls, 1273. The name of Nicholas turncotel in the Ramsey Cartulary, 1252, where *cotel* is an old diminutive form of *coat*, suggests that *turncoat* itself must be older than the N.E.D. record of 1557. The phrase "to drink at pin," referring to the pegs which marked the measures in large tankards, is not found earlier than 1655. William drinkepin is in the Ramsey Cartulary, 1206. Even *farewell*, as the surname of Robert farewel (Close Rolls, 1242–7), is more than a century earlier than the N.E.D. record (1374).

In the list before me are fifty-five compounds of *-head*, some of which, e.g. Broadhead, Whitehead, are still fairly common. Few of these are in the N.E.D., though many of the corresponding adjectives are recorded, e.g. broad-headed (1530), with which cf. Emma brodhevid (Durham Eyre Rolls, 1243). It is curious to compare the modern *fathead* (N.E.D. 1842) with John ffathevit (Cockersand Cartulary, 1220). Redhead is common as a surname from the thirteenth century, though not recorded by the N.E.D. till 1664, and Adam rudipat (Fines Rolls, 1199–1216) is a century earlier than the first hitherto known occurrence of the simple *pate* (*c.* 1305). *Armful* is not given, in any sense, by the N.E.D. till 1579. Adam fayrarmful is in the Lanc. Assize Rolls for 1246–7. *Body*, in the sense of person (cf. *busybody*), dates from 1279. Eustace frebodi is in the Leicester Records for 1206–7. Corresponding to the adjectives *leather-mouthed* (N.E.D. 1653), *sweet-mouthed* (*ibid.*, 1611), *fair-haired* (*ibid.*, 1626), *long-legged* (*ibid.*, 1590), *good-hearted* (*ibid.*, 1552), *brown-eyed* (*ibid.*, 1865), we find the names of Alan lethermouth (Patent Rolls, 1330–4), William swetemouth (Freemen of York, 1346–7), John fayerher (Patent Rolls, 1258–66), Geoffrey godherte (Close Rolls, 1204–24), John bruneye (Patent Rolls, 1313–17). The first N.E.D. record of *flaxen*, applied to the hair, is from Shakespeare (Hamlet, IV. v. 196); but cf. Richard flaxennehed (Hundred Rolls, 1273), Hugo flaxenebert, i.e. beard (*ibid.*). Of the hundreds of such formations enumerated in Miss Pilkington's thesis, only a very few have been granted the hospitality of the N.E.D. Here are a few with contrasted dates :

N.E.D. Record.		Surname Record.
bullhead (= blockhead)	1624	John boleheved (Hundred Rolls, 1273).
giddyhead	1641	William gidyheved (City Letter-Books, 1327–77).
greybeard	1579–80	Richard greyberd (Hundred Rolls, 1273).
pink-eye (pink = narrow)	1575	Henry pinkeneye (*ibid.*).
meal-mouth (= mealy-mouth)	1546	Henry millemuth (Northumb. Assize Rolls, 1279).
cherry-cheek	1447	William chericheke (Patent Rolls, 1323–7).
sheepshank	1675	Thomas shepeshank (Close Rolls, 1223–7).
spindleshank	1570	Adam spindelschanke (Norwich Records, 1269).
lightfoot	*c.* 1440	Boidinus lighfot (Close Rolls, 1224–7).
rawbone	1593	Peter rabayn (Patent Rolls, 1321–4).

Out of a large number of compound costume-names I will take only two obsolete terms familiar to students of Chaucer. Sir Thopas wore "jambeaux," i.e. leg-armour, of *quyrboilly*, a material of boiled leather (French *cuir bouilli*), and the Clerk of Oxenford had a threadbare *courtepy*, i.e. short pea (jacket). Both words are a little older than Chaucer. The first is in Barbour (1375), the second in Langland (1362). But William curbuill (Percy Cartulary, *c.* 1240) and Henry curtepie (Patent Rolls, 1258–66) point to a probably much greater antiquity of both.

Among nicknames taken from animals, birds occupy the chief place. Some of the compounds, e.g. Sparrow-hawk, Nightingale, Woodcock, are of Anglo-Saxon origin, but there are also many which appear to be of Middle English formation. The following occur, among others, as surnames :

N.E.D. Record.		Surname Record.
bullfinch	1570	Lawrence bulfinch (Inquisitiones post Mortem, 1316–27).
kingfisher	*c.* 1440	Henry le kingesfissher (Patent Rolls, 1321–4).
nuthatch	*c.* 1340	Richard notehach (Patent Rolls, 1281–92).

The odd character of this type of name is well illustrated by Thomas gosonthegrene (goose on the green) (Norwich Records, 1289). Names other than those taken from birds which antedate considerably the N.E.D. are—

N.E.D. Record.		Surname Record.
bell-wether	*c.* 1430	Richard bellewether (Patent Rolls, 1321–24).
church-mouse	1731	Robertus chirchmus (Pipe Rolls, 1165–6).
hog-lamb	1818	Stephen hoglambe (Patent Rolls, 1313–17).
mouse-hunt (= weasel)	1481	Rogerus mushunte (Pipe Rolls, 1160–1).
puss-cat	1565	Robert pusekat (Northumb. Assize Rolls, 1256).
wild-cat	*c.* 1400	Ricardus wildecat (Pipe Rolls, 1175–6).

From the remaining classes I select a few miscellaneous examples:

N.E.D. Record.		Surname Record.
free-woman	1611	Matilda frewoman (Hundred Rolls, 1273).
gentleman	1275	Adam gentilman (Domesday of St. Paul's, 1222).
lady-love	1733	Thomas lavedylove (Lanc. Assize Rolls, 1285).
penny-father (= miser)	1549	William penifader (Close Rolls, 1288–96).
penny-man	*c.* 1440	William peniman (Hundred Rolls, 1273). "An impersonation of money, also called Sir Penny" (N.E.D.).
goodspeed	1526	Radulph godisped (Hundred Rolls, 1273).
sweet-love	1560	Peter swetlove (*ibid.*).
barleycorn	1382	Geoffrey barlicorn (*ibid.*).
haycock	*c.* 1470	Henry haycock (Patent Rolls, 1258–66).
honeydew	1577	Robert honiedewe (Salisbury Cartulary, 1230–40).
may-bush	1579	William mabussh (Close Rolls, 1313–18).
oat-hull (= husk)	1607	William otehule (Pipe Rolls, 1182–3).
pease-cod	1362	Robert pesekod (Charter Rolls, 1257–1300).
flint-hard	1594	James flinthard (Hundred Rolls, 1273).
halfpenny	*c.* 1330	Simon halpenny (Charter Rolls, 1226–57).
lodestar	*c.* 1386	James lodsterre (Hundred Rolls, 1273).
ninepence	1603	Adam ninepenyz (Bishop Kellawe's Register, 1280–1345).
plough-day	1550	William plouday (Hundred Rolls, 1273).
snowball	*c.* 1400	Pavia snawball (Fines Rolls, 1246–72).
twopence	*c.* 1450	Walter twapens (Patent Rolls, 1330–4).

The examples quoted in this short article are mostly chosen as illustrating a considerable divergence of dates between dictionary records and the proved existence of the compound as a nickname. There are also cases in which a difference of only a century may be very significant. The N.E.D. dates *husbandman* from *c.* 1330; but the name of John husebundeman in the Patent Rolls for 1225–32 seems to prove that the compound must have been familiar in late Anglo-Saxon, for no man would be officially described by a word which was not generally intelligible and of fairly ancient date.

The Structure of the Universe

By the Rev. Hector Macpherson, M.A., F.R.A.S., F.R.S.E.

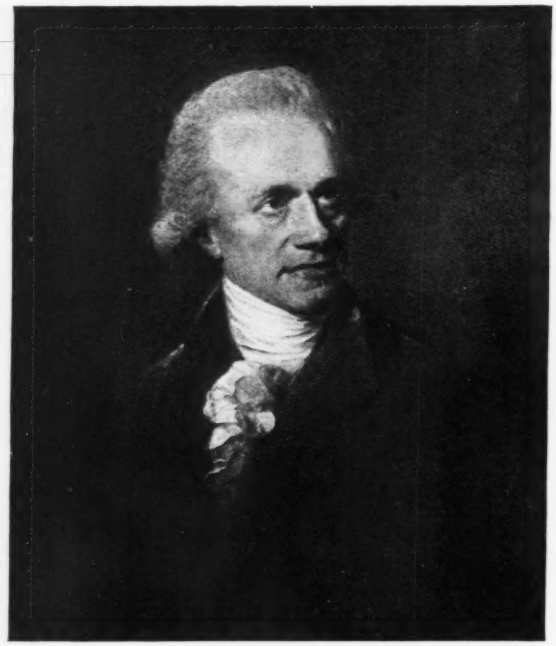
I. Observation and Theory Before 1900

In Roman and mediæval times the human mind was not exercised by such questions as the structure of the Universe. The general order of nature was believed to be fairly well known. The earth was the hub of the Universe, fixed and immovable in the centre of creation. Round the earth, at various distances and in different periods, revolved the sun and moon and the five planets or wandering stars, while beyond was the sphere of the "fixed" stars. But this simple and easily comprehended view of the universe had to be abandoned when in the early seventeenth century the truth of the Copernican system was demonstrated by the discoveries made by means of the newly-invented telescope. The earth was perceived to be merely one—and by no means the largest—of several planetary worlds revolving round the sun; so far from being the centre of creation, our world was seen to occupy a very humble place in the scheme of things.

At first the attention of astronomers was practically confined to the motions and physical condition of the various bodies in the solar system. When Galileo, Kepler, Newton, or Huyghens dealt with the "fixed" stars, they did so incidentally, and their views concerning them were mere guesses. Before the time of Herschel, the stars were observed chiefly as convenient reference-points for the determination of lunar and planetary positions and motions. One important discovery was made almost accidentally as far back as 1718. In that year Halley announced that the four bright stars, Sirius, Arcturus, Aldebaran, and Betelgeux were distinguished by a proper motion, and in the course of the eighteenth century about fifty-seven proper motions were detected. About the middle of the century Thomas Wright, of Durham, put forward his theory of the sidereal system, and in this line of speculation he was followed by Kant in 1755, and by Lambert in 1760.

The problem of the construction of the universe was, however, first tackled in earnest by Sir William Herschel. Previous speculations were not based on observation, so at the very beginning of his astronomical career, Herschel commenced the systematic study of the stars—their distribution and motion—with a view to formulating a definite theory of the sidereal system. His brilliant discovery of the solar motion was but a preliminary to his greater research.

"A knowledge of the construction of the heavens," he wrote in 1811, "has always been the ultimate object of my investigations." In 1784, in his first paper on the subject, he described his method of star-gauging, which, he said, "consists in repeatedly taking the number of stars in ten fields of view of my reflector very near each other, and by adding their sums and cutting off one decimal on the right, a mean of the contents of the heavens, in all the parts which are thus gauged, is obtained." In 1785 Herschel outlined his theory of the universe. "That the Milky Way," he said, "is a most extensive stratum of stars of various sizes admits no longer of the least doubt, and



SIR W. HERSCHEL.
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that our sun is actually one of the heavenly bodies belonging to it is evident." The distant nebulæ were looked upon as external universes, and in 1785 he remarked that he had discovered 1,500 universes. Herschel made two important assumptions—that his gauging telescope was sufficiently powerful to penetrate to the limits of this stratum, and that the stars were distributed with some approach to uniformity. Obviously, if these assumptions are granted, the number of stars in any given region of the heavens becomes a criterion of the depth of the stratum in that direction. Herschel was thus enabled to estimate the possible dimensions and shape of the sidereal system. He sketched it as a cloven disc of irregular outline, extending much farther in the direction of the Milky Way or Galaxy than in that of the galactic poles, the cleft representing the division in the galactic stream. The sun he believed to be almost, but not quite, centrally placed, being slightly nearer to the north galactic pole than to the south, and perceptibly closer to the boundaries of the system in the direction of Canis Major than of Aquila.

On the disc-theory, then, the sidereal system was believed to be of limited, though vast, dimensions, and the nebulæ were regarded as external universes which appeared irresolvable through immensity of distance. As his investigations progressed, Herschel was obliged to modify his early conclusions. He came to believe, correctly, that many of the nebulæ were gaseous objects, and not clusters of stars at vast distances. In 1811 he definitely abandoned his belief—never very confidently held—of an equal scattering of stars. "An equal scattering of stars," he said, "may be admitted in certain calculations; but when we examine the Milky Way or the closely compressed clusters of stars, of which my catalogues have recorded so many instances, this supposed equality of scattering must be given up." He did not altogether abandon the supposition, for "a certain properly modified equality of scattering" formed the basis of the second method of star-gauging, which he applied to the Galaxy in 1818. The first disc-theory, however, was abandoned, and Herschel did not put forward another definite hypothesis. At the close of his career he regarded the sidereal system as of greater extension in the direction of the Galaxy than he had formerly believed. He found that "the utmost stretch of the space-penetrating power of the 20-foot telescope could not fathom the profundity of the Milky Way," and he maintained that, "when our gauges will no longer resolve the Milky Way into stars, it is not because its nature is ambiguous, but because it is fathomless." At the close of his investigations, therefore, Herschel viewed the universe as a more flattened disc than he did at the beginning, and he appears still to have looked on the Milky Way as in the main an optical phenomenon, while conceding the objective reality of the regions of streaming and clustering.

Herschel's successor in the study of star-gauging was his son, Sir John Herschel, who completed his father's work by a survey of the southern hemisphere. Sir John Herschel, however, does not appear to have been aware of the gradual progression in his father's views, for in his *Outlines of Astronomy* he reproduced the disc-theory of 1785, referring to it as "the view of the construction of the starry firmament taken by Sir William Herschel." The younger Herschel nowhere put forward a definite theory of the structure of the universe. He did not, however, adhere slavishly to the views put

forward by his father. Indeed, in 1836 he wrote from South Africa to Sir William Rowan Hamilton : " It is impossible to resist the conviction that the Milky Way is not a stratum but a ring."

The first astronomer who made an exhaustive study of the elder Herschel's papers and noticed his reiterations of opinion was Wilhelm Struve, the German director of the Russian National Observatory at Pulkova. Struve was also the direct successor of Herschel as an original investigator of the problem. His own study of stellar distribution led to the formulation in 1847 of his modification of the original disc-theory. The universe was, he believed, of finite thickness—the stars being obviously limited in number in the direction of the galactic poles—but of infinite extension in the direction of the Galaxy. He maintained, indeed, that this was borne out by Herschel's later investigations, and that when Herschel spoke of the Galaxy as fathomless, he meant that it was unfathomable. Along with this view of an infinite extension in the galactic plane, Struve advanced his theory of the extinction of light in space—maintaining that the more distant of the galactic star-clouds were rendered invisible by the extinction of light. Struve's hypothesis was rejected by the majority of his contemporaries ; and their rejection has been justified by subsequent research. Grant and the younger Herschel showed that in important respects it failed to explain the observed facts ; while Encke demonstrated that the theory was based on five assumptions, all of which were questionable.

The work of Proctor in England may be regarded as analogous to that of Struve on the Continent. He made an exhaustive study of Herschel's papers, and proved beyond a doubt that the detailed disc-theory of 1785, with its corollary—the hypothesis of island universes—had been definitely abandoned by Herschel. His own views of the universe represented a reaction from the views of Struve ; he regarded the universe as much less extended in the plane of the Galaxy than Struve, or even Herschel, had believed. " Where," he wrote, " Herschel thought he was penetrating to the extreme limits of the sidereal system, he was in reality only analysing more and more searchingly an aggregation in which many orders of stars were mixed up. What he failed to do was not, as he supposed, to sound the Galaxy, but to recognise as separate stars the minutest order of orbs included within such aggregations." Proctor believed the stars composing the Milky Way to be smaller and more closely crowded together than those in the vicinity of the sun. In his view, therefore, the extent of the sidereal system was much less than Herschel had believed it to be, although he admitted that we " are still bound to accept a considerable extension of our system in the galactic plane as fairly deducible from the gauges of Sir W. Herschel."

In 1870 Proctor plotted on a single chart all the stars, to the number of 324,198, contained in Argelander's *Durchmusterung*. This chart revealed the aggregations of the brighter stars towards the galactic plane—a discovery abundantly verified by the independent work, years afterwards, of Schiaparelli and Gore—and also the connection between bright stars and the nebulous light of the galactic background. " It is," he said, " utterly impossible that excessively remote stars could seem to be clustered exactly where relatively near stars are richly spread." The general conclusion which Proctor reached was that " the sidereal system is altogether more complicated, altogether more varied in structure, than has hitherto been supposed. Within one and the same region coexist stars of many orders of real magnitude, the greatest being thousands of times larger than the least. All the nebulæ hitherto discovered, whether gaseous or stellar, irregular, planetary, ring-formed, or elliptic, exist within the limits of the sidereal system. They all form part and parcel of that wonderful system whose nearer and brighter parts constitute the glories of our nocturnal heavens."

The excess of bright stars on the Galaxy was interpreted by Proctor as indicating that the bright and faint stars were comparatively close together, and in this he was followed by Gore. Celoria, however, interpreted the fact as indicating the existence of two galactic rings, while Gould believed the " secondary galaxy " of lucid stars to be due to the existence of a flattened cluster of bright stars comparatively close to the sun. This suggestion, however, did not receive much attention, and was rejected by both Gore and Newcomb. The former astronomer, writing in 1898, regarding Kapteyn's revival of Gould's suggestion in another form, expressed the view that " the sun is a member of a cluster of stars, possibly distributed in the form of a ring, and that outside this ring, at a much greater distance from us than the stars of the solar cluster, lies a considerably richer ring-shaped cluster, the light of which, reduced to nebulosity by immensity of distance, produces the Milky Way gleam of our midnight skies."

This conclusion, however, was not altogether supported by the exhaustive investigations on stellar distribution carried out by Seeliger, of Munich, from 1884 to 1898. Newcomb, writing in 1901, referred to these researches as " the most thorough study of the distribution of the great mass of stars relative to the galactic plane." Dealing with over 100,000 stars, Seeliger demonstrated the gradual increase of the number of stars from each of the galactic poles to the Milky Way. Now, if the Galaxy were simply a ring of stars surrounding a star-sphere, the number of stars

would increase not gradually, but suddenly near the boundary of the ring. "The Milky Way," said Seeliger, "is no mere local phenomenon, but is closely connected with the entire constitution of our stellar system." Seeliger, in thus emphasising the fundamental importance of the galactic zone, was led nearer to the standpoint of the elder Herschel.

At the close of the century, several estimates had been made of the possible extent of the stellar universe. When the original disc-theory was propounded by Herschel, the actual distances of stars were unknown; but he assigned to the universe in its greatest extension a diameter 850 times the mean distance of stars of the first magnitude—the thickness of the disc, in the direction of the galactic poles, being 155 of these units. More definite estimates were possible after the measurements of stellar parallaxes had indicated the scale on which the universe is built. Newcomb, in 1901, estimated the distance of the stars at the boundary of the universe as 3,000 light-years[1]; and as the sun was believed to occupy a fairly central position, this indicated a diameter of 6,000 light-years. Seeliger, on the other hand, placed the limits of the universe at 9,000 light-years from the sun, the diameter being about 18,000 light-years. More modest estimates were adopted by other competent authorities.

At the close of the century, it was believed to be definitely established that all the star-clusters and nebulæ were situated within the stellar universe. The "island universe" theory which Herschel put forward as the corollary to the disc-theory, but afterwards virtually abandoned, appealed to the imagination, and retained its place for many years in popular volumes on astronomy. But it did not survive the vigorous criticism of Proctor, Gore, and other writers. Its partial revival during the last decade has been one of the most remarkable features of modern astronomy.

The problem of the construction of the universe may be attacked from three different standpoints—stellar distribution, motion, and distance. The earlier astronomers were forced to concentrate on ascertaining the facts of stellar distribution, and had to be content with deductions from these facts. Even down to the close of the nineteenth century, the known motions and distances of the stars were too few and in many cases uncertain to warrant the formulation of a hypothesis based upon them. Mädler, it is true, made a bold attempt to locate the centre of the sidereal system from a discussion of proper motions, which seemed to point to Alcyone, the chief star of the Pleiades, as the centre of the universe; but his failure indicated clearly that the time was not ripe for such generalisations. The twentieth century, however, has witnessed a remarkable extension of our knowledge of the stellar system. Not only have the refined measures of parallax and of proper and radial motion made during the second half of the last century contributed to this, but new methods of measuring the absolute magnitudes of individual stars and of stars in clusters have been devised, and from these measures the distances of large numbers of celestial bodies have been computed. To a consideration of these recent advances and discoveries a second article will be devoted.

[1] A light-year is the *distance* travelled by light in a year. Light travels at the rate of 186,000 miles per second.

NOTE.—A bibliography will be given next month. The best book on this part of the subject is that by the author on *Herschel* (S.P.C.K., 1*s.* and 2*s.* 6*d.*), from which, by kind permission, the photo of Herschel is reproduced.—ED.

The Discoveries in Crete

By George Glasgow, B.A.

(*Continued from October No., p.* 316)

VIII

THE Cretans had a system of writing as long ago as 2500 B.C. The language therein embodied is still a mystery to us, in spite of Sir Arthur Evans's monumental work *Scripta Minoa* (1909). One hopes that in a further volume Sir Arthur may have found a clue to the mystery, but up to the present the bleak fact remains that there is no adequate starting-point for any attempt at interpretation. If only a bilingual inscription could be found—a Cretan document, that is, side by side with a translation in some known language such as Egyptian—a start could at once be made.

It was inevitable that the art of writing should be evolved early in the history of man. Even in the most primitive stages of life there would be the elementary necessity, for instance, of identifying one's own property, and for this the most likely means would be some system of marking. Then, again, the development of communal life would entail the duty of keeping appointments, or of doing a particular thing at a particular time. It would, one thinks, have been too much of a strain, even for the mind of a Stone Age man, to keep all the details of his daily, still more of his annual, routine in his head, and the handkerchiefs of those remote days (assuming, as one must, that they had any) may not have been of such a material as to lend themselves readily to mnemonic knots. It is quite conceivable, as an instance of the sort of necessity that would arise, that at a given time it could be calculated how many days ahead the provisions in hand would last, and when, therefore, the hunter must be ready for the hills. He might prepare a handy reminder by roughly drawing a spear-head, say, together with a pictographic representation of some

commonplace event that was to take place at the same time, and by hanging the picture up in an obvious spot.

One's range of activity would increase as time went on, and it might conceivably be necessary to deliver a message to a man over on the other side of the valley in circumstances where one could not take it oneself. Such a contingency would produce some form of written message, for the message might be private or unsuitable for oral transmission by a third party. To give a concrete example from later times [1]: Proitus wanted to kill Bellerophon, but did not want to do it himself; he therefore sent the doomed man to the King of Lycia "with letters of introduction written on a folded tablet, containing much ill against the bearer . . . that he might be slain." It would have been tactless to transmit such a communication orally by the bearer.

Fifty, even forty, years ago it was the general doctrine of Greek scholars that the Homeric poems were never written down till long after they were composed, perhaps even, so some thought, not until 560 B.C. Till then, we used to be taught, they were preserved wholly by memory and by oral transmission. But on the strength of the above passage from Homer —the only passage in either *Iliad* or *Odyssey* where writing is mentioned—Andrew Lang in 1883 argued that the art of writing must have been known to the early Greeks. "It is almost incredible," he said, "that the quick-witted Greeks should have neglected an art which met them everywhere in Egypt and Asia." He argued better than he knew. Not only was the art of writing known to the early Greeks, but it was known to their forerunners a few thousand years earlier, forerunners whose very existence was not suspected when Andrew Lang wrote. Curiously there had been found no trace of writing in the Mycenæan remains, although this fact has since been shown to be due to mere chance.

In 1893 Sir (then Mr.) Arthur Evans caused general astonishment by communicating to the Hellenic Society his discovery of the fact that certain seal stones which he had found in Greece, and which had been assumed to be Peloponnesian, were in fact Cretan. This startling revelation was clinched during the years that followed by the discovery of further specimens of Cretan writing. Excavation in Crete was started in 1900, and the first year's work yielded up hundreds of clay tablets inscribed with Cretan writing. Was Homer writing fairy stories when he made Proitus send his doomed Bellerophon to Lycia with his "folded tablet"? Or did he know that the Lycians were colonists from Crete?

A tentative sketch of the successive phases through which the art of writing passed may be made, even if it largely depends upon unconfirmed surmise. The temptation to fill in the gaps by what seems reasonable conjecture is hard to resist.

Minoan writing must have started, quite naturally with simple pictographs, such as have, in fact, been found—simple pictures of a man, a leg, a ship, representing a definite thing that it was desired to indicate. They are called "ideographs" because they signify

THE CUP-BEARER.

This life-sized portrait is thus described in chapter v of the present series (DISCOVERY, August 1920, p. 249): "In a narrow corridor [of the Palace at Knossos] was found the fresco painting of the cup-bearer, an astonishing work of art. It represents a Minoan youth of stiff but not unpleasing dignity, carrying a gold and silver vase before him. The fresco had fallen into the corridor when the connecting wall broke down."

[1] Homer, *Iliad*, vi. 169.

a single idea. They next developed into "hieroglyphs," that is, pictures which had acquired by association a certain use among the people who employed them, but whose original meaning has been lost, and can now only be inferred. In the parallel case of Egyptian hieroglyphics, guessing at such meanings has been shown to be dangerous work, for in many cases the established interpretation is far other than what one might have supposed.

The first pictographs were evolved in the Early Minoan period (*c.* 2800–2600 B.C.), and are found on seal stones. It may fairly be assumed, therefore, that in Crete the first method of writing down ideas was by seal impressions. By the Middle Minoan period the seal stones are elongated, and contain a succession of designs, by which a connected chain of ideas could be reproduced. The lines of pictures are sometimes read from left to right, sometimes from right to left, a feature in which, as in others, they resemble the Hittite system of writing. In all cases the document is read in the direction in which the figures it contains are facing. *Scripta Minoa* (p. 203) gives a typical example of this species: namely, a picture of a ship with two crescent moons, of which the probable meaning was a voyage of two months' duration.

The next step in the evolution of writing came, no doubt, when phonetic values were assigned to the pictures; that is, when the sound made in pronouncing the name of a given thing or person or action became associated with the conventional ideograph which represented that thing or person or action. When that happened, the same ideograph began to be used in writing out other, more complex, words in which the same *sound* occurred, although in *meaning* there was no connection with the original pictograph. To take a hypothetical example. Suppose we were in that stage of evolution to-day. We may have formed the habit of denoting an axe by a simple picture of that instrument; thereafter the sign of an axe would have become a symbol for spelling the same sound whenever it appeared in any other word. In spelling the word "accident," for instance, we should start with the picture of an axe. This sort of thing seems to us mere "punning," but it would cause no more difficulty or hesitation to the primitive writer whose attitude we are reconstructing than it would have, say, to Mr. Weller senior, to whom the relation of the written to the spoken word and of words to things was still mysterious. Once begun, the method would be eagerly applied to fresh words.

The first attempt at "syllabics," or the writing out of a word by separate symbols for its separate syllables, was made more intelligible by the use of "determinatives." By "determinative" is meant a pictographic representation of the idea denoted by the whole word. These we find appended to the spelling of a word in order to give the reader at least some inkling as to whether the word denoted mineral, animal, or vegetable. A man's name, for instance, would be followed by a picture of a man.

The physical strain involved in drawing pictures every time one wanted to write down a word or two would obviously soon become intolerable. It is not therefore to be wondered at that, by the time of the Middle Minoan III period, the hieroglyphics have been simplified into conventional signs which are easier to make. Herein is the germ of what we call "linear" script, that is, of a system of writing based on a set of regular forms, such as our own alphabet. By the Late Minoan I period there was a full linear script in use throughout Crete, and it was extended to Melos and Thera. Sir Arthur Evans has entitled this script "Class A" to distinguish it from a parallel form of it which was introduced in the next period (L.M. II), and which he calls "Class B." The latter is not a different script, but merely a variation introduced, it is supposed, by a new dynasty at Knossos. Most of the Knossian tablets that have come down to us belong to the "Palace period," and are written in the Class B style.

It was the usual practice to write the inscriptions with a stilus, that is a pointed rod of metal, on a clay tablet, and this is the form of most of the inscriptions that have been preserved. It is possible that wooden tablets covered with a layer of wax were also used; but even if they were, none of them, of course, could have survived the burning of the palaces. More interesting still is the fact that pen and ink must have been used even in those remote times. This fact is established by the discovery of two cups (M.M. III) which are inscribed in ink. There can be little doubt, therefore, that long documents and any literature there happened to be were written in ink on papyrus. It is probable that we shall have to make up our minds to the complete loss of all such literature, for Cretan soil lacks the dryness of the Egyptian. If our worst fears prove true, we may experience the final anti-climax of the discovery that the clay tablets, when read, will contain nothing after all but lists and bills and the like.

It is indeed obvious that many of the tablets consist of bills or inventories. Although we cannot yet understand the language of the script, it has been found possible, by studying the clay tablets, to reconstruct the system of numbers that was used. We have, for instance, what is evidently an inventory of arrows, a record surmounted by a picture of an arrow. From this and other records it is apparent that thousands were expressed by "diamonds," hundreds by slanting lines, tens by circles, units by

straight lines, quarters by a small " v." The highest number recorded is 19,000.

Although it is true, as already stated, that scholars still await a clear starting-point for transcribing the Cretan script, there is one interesting and important point already established by Sir Arthur Evans. He has proved that the Phœnician alphabet, which had always been supposed to be the original source of the Greek alphabet, and therefore of the Latin alphabet from which comes our own, was itself derived from Crete.

There are in existence three fragmentary inscriptions, two of which were found not long ago by Professor R. C. Bosanquet at Præsos, in Crete—near to Mount Dicte, and not far to the north-east of the boundaries of Knossos—which are written in Greek characters, and are therefore quite legible to us, but which contain a language which is not Greek. Is it the language of the Minoans? On this thorny question I must leave it to Professor Conway, who has examined them at length in the *Annual* of the British School at Athens,[1] to find what can be said—if anything can be —to the readers of DISCOVERY.

[1] Vol. viii, p. 125, and vol. x, p. 115

(To be concluded)

Wireless Telephony

By Lieut.-Col. C. G. Crawley, M.I.E.E.

IN communicating by speech in the ordinary way, energy is transferred from the speaker to the listener in the form of air waves, these waves being produced by oscillations, to and fro, of the little particles of air. These air oscillations are set up by the voice, and are received as air oscillations in the ear, where they set the drum in vibration, so producing the sensation of sound. In line telephony the air oscillations set up by the voice actuate an instrument, the microphone transmitter, which varies the strength of the electric current flowing along the line. These variations of the current work the receiving instrument, the telephone receiver, in such a way as to produce sound waves precisely similar to those which caused the variations at the sending end. In this way the energy of the air oscillations at the transmitter is transformed into the energy of current variations in the line, and retransformed into sound at the receiver.

In the case of wireless telephony the procedure is very similar, except that the variations of a current flowing in a system of elevated wires, called the aerial or antenna, produce variations in the continuous stream of ether waves which this current causes to be radiated in all directions, and these ether waves cause a current with similar variations to flow in any other aerial which they meet.

In ordinary speech, therefore, air waves proceed direct from the sender to the receiver; in line telephony they vary an electric current which produces similar air waves at the receiver; and in wireless telephony they vary an electric current which produces variations in ether waves, which in their turn produce similar air waves at the receiver.

The medium by which energy is transferred in line telephony is the wire connecting the sender to the receiver, whereas in wireless telephony the medium is the ether which connects all senders to all receivers, and it is this fact which constitutes the great advantage of the latter, viz. all senders are at no cost automatically connected to all receivers. It must not be thought, however, that such a great advantage can be attained without dragging some serious disadvantages in its train. The use of the same medium, for instance, leads naturally to difficulties in selectivity—that is, one communication being interfered with by others, or by electrical disturbances in the ether itself, such as those caused by lightning. Interference between various communications is overcome to a great extent by arranging that different lengths of waves in the ether are used for different communications, the apparatus for one communication being adjusted to respond much better to ether waves of one special length than to those of any other. When the apparatus at each end are thus arranged for transmitting and receiving respectively ether oscillations of the same rate, they are said to be in tune with one another, and the greater the number of different communications required, the greater are the number of various rates of oscillation that must be arranged for. Now, it is just this requirement that makes an extensive network of different communications very difficult and often impracticable, because for good working over approximately the same range, the various wave lengths that can be economically used are strictly limited. Wireless telegraphy makes use also of ether waves, and requires the same wave lengths as are suitable for telephony, so that the available field for selection is still further reduced. With line telephony, on the other hand, there is of course no such limitation, separate wires being used for each of the various communications.

The other trouble mentioned, that of interference from electrical disturbances in the ether, is also very serious, just as it is in the case of wireless telegraphy. These disturbances, or " atmospherics," are very troublesome indeed in tropical climates, and even in temperate latitudes they produce much interference in the summer months. For " broadcasting " a message—that is, sending a message out to all stations

within range which are adjusted to receive it—the difficulty as regards wave lengths is of course reduced, and some interesting demonstrations on these lines have recently been given in this country. On one occasion last June, Dame Melba sang into a transmitter at the Marconi Company's station at Chelmsford, and the songs were heard clearly at many wireless receiving stations on land and sea up to distances of several hundreds of miles. It is possible that such a broadcasting system might be utilised for news messages to daily papers, and tests have recently been carried out for the Press Association. These tests, however, showed that such an arrangement was not suitable for immediate use.

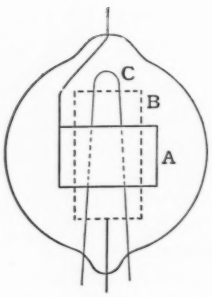


FIG. 1.

A three-electrode transmitting valve. A is a plate of sheet metal. B is a cylinder of narrow mesh wire gauze. C is a wire filament. The glass vessel is highly evacuated.

In comparison with wireless telegraphy, the advances in wireless telephony were extremely slow until about six years ago, when the Three-Electrode Thermionic Valve was introduced as a generator of wireless waves. Since then, however, such rapid progress has been made that its great future is already well assured. The principal reason why telephony lagged so far behind was that a continuous radiation of uniform ether waves which could be modulated by the voice was essential, whereas in telegraphy a radiation of groups of waves sufficed, a radiation such as was obtained from the spark generators used in all the earlier wireless telegraph transmitters. The first real attempts at wireless telephony were made possible when arc generators and high-frequency alternators were introduced. Even these, however, did not produce radiation of exactly the sort required, and it was undoubtedly the introduction of the Three-Electrode Valve as a generator that gave wireless telephony a fair start.

The Three-Electrode Thermionic Valve (Fig. 1) consists essentially of a vacuum bulb similar to the ordinary incandescent lamp, but with two metallic electrodes inside the bulb in addition to the filament. When this instrument is connected with suitable circuits to a source of electric power, electric oscillations—that is, electric currents oscillating at very high speeds—

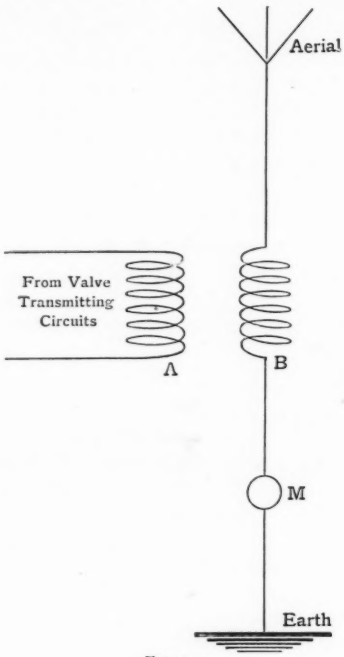


FIG. 2.

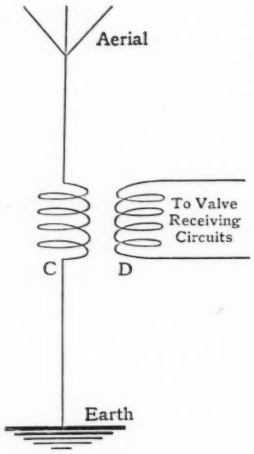


FIG. 3.

are generated, and when these currents are caused to flow in an aerial, a continuous stream of uniform ether waves is radiated. For telegraphy, these oscillations, and hence the waves, are broken up into short and long groups by a signalling key, corresponding to the dots and dashes of the Morse Code; and for telephony they are modulated by the voice speaking into a microphone, just as the current in the line is modulated in line telephony. A common form of microphone consists of a small chamber filled with carbon granules through which the current flows, the current remaining constant so long as the granules are quiescent, but varying in strength owing to the varying electrical resistance, as the granules are made to vibrate by the voice.

The microphone transmitter may be placed as in Fig. 2 at M in the aerial itself, so as to modulate the

currents in the aerial, or may be placed in the valve circuits, so as to modulate the currents at the source, the energy in either case being transferred from the valve circuits to the aerial by the currents in coil A, inducing exactly similar currents in coil B. At the receiving end (Fig. 3), the currents produced in the aerial by the wireless waves are exactly similar in form to those in the sending aerial and flow through coil C, inducing exactly similar currents in coil D, which is connected to the valve receiving circuits in which the telephone receiver is inserted. The aerial in land and ship stations is supported by masts, and in aircraft is let down as a trailing wire or is made up as a coil in the aircraft itself. The " earth " consists of metal plates or wires in the ground or water, or, in the case of aircraft, metallic portions of the fusillage.

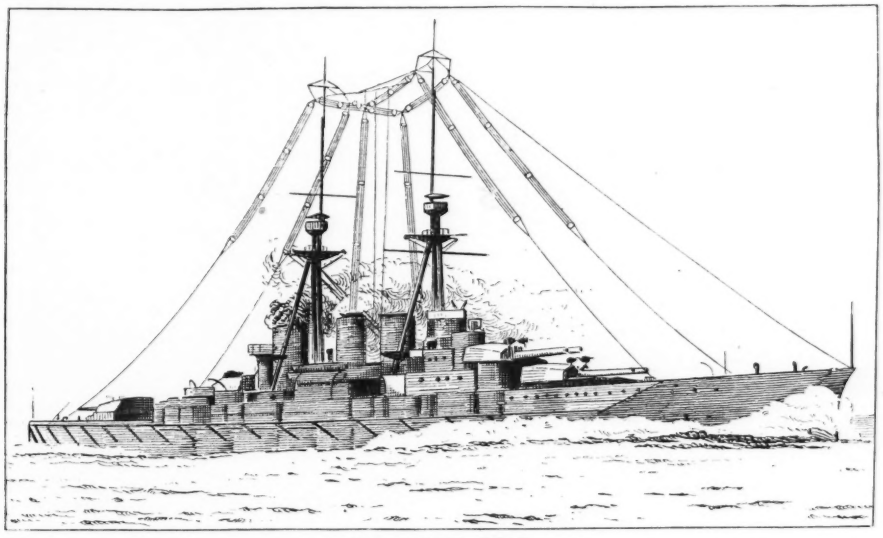


FIG. 4.—SHIP AERIAL.

It was only a year or so before the outbreak of war that experiments were commenced with wireless telephony using the Three-Electrode Valve as a transmitter, and during the war nearly all work carried out in Europe on wireless telephony was directed towards the development of small sets, especially in connection with aircraft. This was largely due to the fact that in aeroplanes the use of wireless telegraphy entailed the pilot or observer being trained as a telegraphist, and acting as such in addition to his other duties, as it was usually impracticable to carry a wireless operator for wireless duties only. Pilots and observers had plenty of other work to get through, and the advantage of having a simple telephone set which could be used with little technical knowledge soon became very apparent. It was in the summer of 1915 in this country that wireless speech was first received from an aeroplane, and there is no doubt that our Flying Corps was the pioneer in this method of aircraft communication. One of the first successful demonstrations of wireless telephone working from aircraft in France was given to Lord Kitchener at St. Omer. Unfortunately, however, the messages from the aeroplane were heard as far away as Lowestoft, and further experiments were prohibited for quite a long time, as it was thought that the enemy might obtain some valuable information by reading our messages.

In 1915 most pilots considered all wireless more as a nuisance than anything else, whereas it has been stated that in 1919 some pilots on the postal routes refused to go up without a wireless telephone. About the time of the Armistice, aeroplanes were normally communicating by wireless telephony with ground stations up to about fifty miles, and with each other up to about five miles, but these ranges have now been more than doubled.

In the United States, during the early part of the war, more time could be spared for experiments with larger sets, and spoken messages were heard at the Eiffel Tower Station in Paris, about 2,300 miles, and sometimes even at Honolulu, about 5,000 miles. Since then other great distances have been accomplished, such as between this country and America, but it must be understood that such long-range working is still in the experimental stage, though its realisation as a commercial proposition is no doubt only a matter of time. There is no great technical difficulty in linking up wireless telephony with line telephony, to allow of the communication being partly

by wireless, and partly by line. It was in this manner that President Wilson when at sea, returning to the United States after the Peace Conference, received telephone messages from his Ministers at Washington, and more recently business conversations have been conducted from this country in the same way with aircraft flying to Paris.

A limitation to wireless not mentioned above, as compared with line telephony at present, is that the receiver cannot break in when the sender is speaking—that is to say, the listener must wait until the speaker has finished before he switches over to his speaking apparatus. This point need not, however, be discussed here, as, although it is just now a serious disadvantage, it will certainly be remedied before very long.

When consideration is given to the present achievements of wireless telephony in light of the fact that the whole subject is in its infancy, it is easy to foresee very great possibilities, even if we cannot quite reach those heights of technical imagination so easily scaled by the daily Press.

Land and Sea in Greek Life

By W. R. Halliday, B.A., B.Litt.

Professor of Ancient History in the University of Liverpool

In theory at least we are accustomed to derive the city state of the ancient world from an agricultural origin; and, in fact, the small farmer in early Greece and Rome formed the backbone alike of the State and its armies. It was the peasant proprietor who defeated the Persian at Marathon at the outset of the fifth century B.C., who conquered Italy for Rome and defeated Hannibal in the third. But both in Greece and Rome, as civilisation developed and became more complex, the peasant farmer tended to disappear, and small-holdings were squeezed out by estates owned by capitalists and worked by gangs of slaves. The attractions of city life helped to drain the rural districts; and sharp-witted townsmen, then as now, affected to despise the country bumpkin.[1] On moral and sentimental grounds the process was to be regretted. At Rome its attendant evils were aggravated by slavery, which transformed the peasant population into a parasitic proletariat of "mean whites," and its results were disastrous; it was due, however, to an economic necessity which the tinkering of reformers was powerless to alter. For the development of large grazing estates with their summer and winter pastures, and the cultivation of products other than corn which involved capital outlay, were economically sounder than the system of corn-growing peasant holdings in a society which had reached a capitalistic stage. In Greece this development did not operate on so large a scale, nor were its results so severely felt; but, none the less, in fourth-century Athens the peasant proprietor was disappearing. Attica had been ruined by the ravages of the Peloponnesian War; and the agricultural revival preached by Xenophon was to be carried out by men of capital like Ischomachus and his father, who could buy up ruined property cheap and work their estate with an overseer and slaves.[2]

The Romans never liked the sea, and it was only the sheer military necessities of the Punic War in the third century B.C. that compelled them for the first time to build a fleet. Indeed, the great Roman poet Lucretius betrays the attitude of his countrymen towards the sea when he opens the second book of his poem on Nature by remarking that it is pleasant to stand safely on the shore and watch less fortunate people on the sea having a bad time.

The Greeks, on the other hand, took early to the sea and became a race of mariners and merchants. Nations, like individuals, have to pay their way in the world. The financial basis of Rome was the spoils of empire. Successful wars concentrated the capital of the world in her hands, and her conquered provinces had natural resources which her citizens could exploit. Rome came to live by financing and "developing." Greek prosperity, on the other hand, was based upon seaborne commerce and the command of the carrying trade in the Eastern Mediterranean. Seafaring was congenial to the Greek temperament, and no doubt its practice reacted upon national character. The same adventurous daring as was shown by her mariners in exploring unknown regions and uncharted seas was displayed by her thinkers, scientists, and philosophers in intellectual fields. That is why the Greeks came to be the founders of Western civilisation. Agriculture and seafaring, then, form the background of Greek civilisation; and these are occupations by which a free man can worthily earn his living. For though mining and manufacture play an increasingly important part in Greek economics, the former was wholly, and the latter mainly, carried out by slaves. The

[1] "Forgive me; I'm an awkward country fool," says Strepsiades when abused for kicking the door of Socrates' Thinking Shop (Aristophanes' *Clouds*, l. 137, trans. Rogers Bell & Sons, 1919. 2*s*.). For the growing contempt of the townsmen for the rustic, see Theophrastus, xiv, with Jebb's notes and references.

[2] See Xenophon, *Œconomicus*. A translation by Dakyns will be found in his *Works of Xenophon*, vol. iii, part 1, p. 197. (Macmillan, 1897.)

Greeks were an open-air people. Their climate encourages the open-air life. They had a correspondingly high standard of physical fitness. They disliked working indoors, and they condemned its physical results. A man's health, they argued, must suffer from being shut up out of the sunlight all day, possibly beside a fire or furnace. And if his body suffered, his mind would suffer too. Such occupations would stunt his mental and moral growth. Industry indoors was no life for a free man. If he has to earn his living, he will do so, they thought, most honourably in the open air as a farmer or sailor.[1] An epitaph in the *Anthology* gives us the alternatives:

TYPICAL GREEK VIEW.

"I am Eteocles, whom the hopes of the sea drew from husbandry and made a merchant in place of what I was by nature. I was travelling on the surface of the Tyrrhenian Sea, but with my ship I sunk headlong into the depths, in a sudden fierce squall. It is not then the same wind which blows on the threshing floor as that which fills the sails."[2]

The lines of Greek development had, in fact, been largely moulded by the physical features of the Balkan Peninsula. About 1000 B.C. the ferment caused by the invasion of the iron-using tribes from Central Europe[3] gradually subsided; and the Ægean area, which had been a seething cauldron of migratory peoples, began to settle down. Now, Greece consists of a tangled mountainous mass with little pockets of plain between its crags. Man cannot live upon mountain-tops of bare limestone, and therefore it was in these pockets, isolated from each other by sea and mountain, in which settlements grew up. This physical isolation bred the peculiar virtues and defects of the city-state: on the one hand an intense love of independence, and on the other the inability to form a successful political combination upon a larger scale. Further, the indented coast-line of Greece, with its main harbours opening towards the homes of older civilisations in the East, and the chains of islands, which offered ready shelter to the early mariner, and, what was even more important to one who had no compass, the perpetual guidance of landmarks, made the Ægean Sea an ideal nursery for early navigation.

The people then settled down in these little plains hedged in by mountains and the sea. It is a law of nature that everything, in order to survive, must adapt itself to its circumstances. So the Northerners had to change their way of life. The Homeric chieftains were still tamers of horses, a pastoral people who reckoned their wealth in oxen; e.g., when Diomed changed armour with Glaucus, Homer remarks what a fool he was to give away arms worth a hundred oxen for arms worth nine. But the country in which the "tamers of horses" were now settled has no wide pasture-lands. Beyond the small arable plain is the rocky mountain. Its prickly scrub will give summer feed for goats and sheep, but is of little use for horses or cattle. In consequence the Greeks ceased to be a pastoral people, and became agricultural.

Below the bare rock of the mountain summits there is a belt of forest, with springs round which green shrubs will grow in the summer when the plain below is parched

[1] See, for example, the treatise of Xenophon already referred to.

[2] *Greek Anthology*, vii, p. 532 (translated by W. R. Paton in the Loeb Series).

[3] See DISCOVERY, vol. i, pp. 226 and 342.

and baked. In the summer, then, you have the shepherds of the mountains taking up their flocks, as they do to-day, to the cooler altitudes where pasture is to be found, and in winter coming down below the snow-level. Their flocks are sheep and goats which they keep for milk, wool, and goats'-hair.[1] The ancient, like the modern, shepherds were a wild and lawless crowd. The mountains are natural hiding-places for fugitives from justice; they are also the no-man's land between us and the enemy-state across the range[2]; and there are sheep-stealers, two-legged and four-legged, to be dealt with. For there are wild beasts in the forest belt. Wolves were so predatory in Attica that a reward was paid for each wolf destroyed, as it was in early days in England. Boars, too, were to be found and hunted in the forest.[3]

Below the mountain and on its lower slopes, where patches could be terraced into fields, lived the small farmer. About his life and habits we know a good deal from the poems of Hesiod (eighth century B.C.).

The farmer, then as now, was a grumbler. The climate of Ascra, where Hesiod lived, was "vile; cold in winter, hot in summer, never good." Of course the winter in Greece is cold. Although the sun is warmer than with us, the piercing winds sweep down from the snow-clad hills. "Wretched days they are," says Hesiod, "all of them fit to flay an ox, and the frosts are cruel when the north wind blows over the earth—then all the immense forest roars, and the beasts shudder and put their tails between their legs, even those whose hide is covered with fur; for with his bitter blast he blows even through them, although they are shaggy breasted. He goes even through an ox's hide; it does not stop him. But it does not blow through the tender maiden who stays indoors with her dear mother." It was a great temptation in this cold weather to spend the day gossiping by the warmth of the forge in the village smithy, which in ancient Greece, as in rural England to-day, was the rustic club. Hesiod warns his pupil against the waste of time. "Pass by the smithy and its crowded lounge in winter-time when the cold keeps men from field work, for then an industrious man can greatly prosper his house"; there is plenty to do indoors mending and making gear.

The other close time is the summer. The Greek harvest is in May. In July and August it is too hot for work, and the ground gets baked as hard as brick.[4] Even Hesiod countenances a rest in the summer. "But when the artichoke flowers [June] and the chirping cicada sits in a tree and pours his shrill song continually from under his wings in the season of wearisome heat, then goats are plumpest and wine sweetest, but men are feeblest because the Dog Star parches head and knees and the skin is dry through heat. But at that time let me have a shady rock and wine of Biblis, a clot of curds and milk of drained goats, with the flesh of an heifer fed in the woods, that has never calved, and of firstling kids; then also let me drink bright wine sitting in the shade, when my heart is satisfied with food; and so, turning my head to face the fresh breeze, from the overflowing spring which pours down unfouled, thrice pour an offering of water, but make a fourth libation of wine."[5]

Old Hesiod must have been a good companion to sit with under the shady rock by the fountain. He was a wise old man with the wisdom of those who live patiently with nature. He knows all about the stars and birds and beasts and flowers. It is they who mark his calendar, and he trusts to the observation of their habits in place of the artificial division of months,

[1] Cattle were kept, as in modern Greece, solely for draught purposes. I remember failing to persuade a Cretan shepherd that it was no traveller's tale, but true, that in England sheep were not milked, but cows were.

[2] Compare the life of the shepherds indicated in Sophocles' *Œdipus Tyrannus*, of which Prof. Murray and more recently Mr. J. T. Sheppard have published translations.

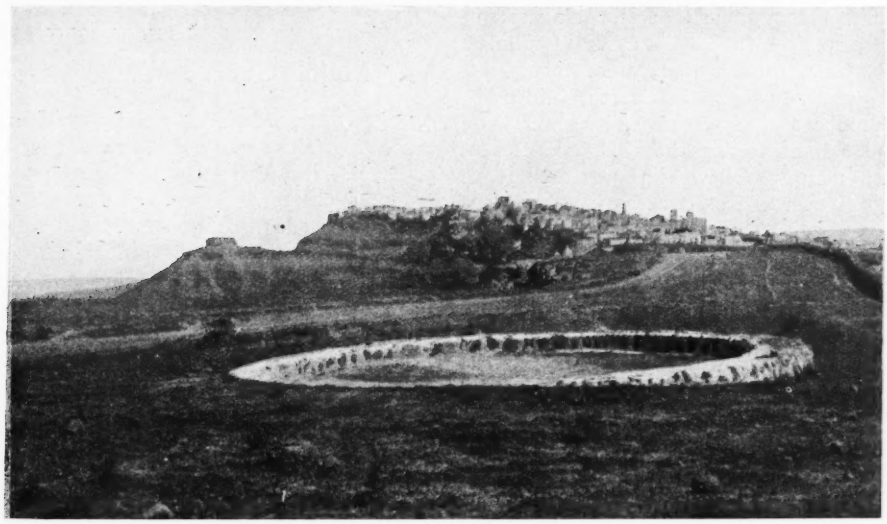
[3] The brown bear was extinct in Attica in the fifth century, but there is interesting evidence of its earlier existence in the bear dance which all Athenian maidens had to perform in honour of the bear goddess, Artemis Brauronia. Lions were well known to Homer, who frequently makes poetical use of their attacks upon flocks and herds. Herodotus gives the rivers Achelous (in Acarnania) and Nestus (on the north coast of the Ægean) as the limits of the distribution of the lion in his day. They attacked Xerxes' sumpter-camels when he was marching through Thrace to the invasion of Greece, and so greatly did they appreciate this new delicacy that they touched, so the historian assures us, neither man nor other baggage animals (Herodotus, vii, pp. 125, 126). Lions were still to be found in Macedonia at the end of the first century A.D. The saga of Meleager and the story of the great boar of Calydon will be familiar. Boar-hunting remained a popular manly sport in Attica down to the fourth century, as references in Aristophanes and the Orators testify. None of these wild beasts are to be met with in Modern Greece, though a few wild goats survive in Crete, and wild pig is fairly common in parts of Asia Minor. I have not myself seen the small brown bear, but was assured that it was to be found in the mountains of Anti-Taurus.

[4] During the war it was necessary to construct a landing-place for Handley-Page aeroplanes near Suda, in Crete. The clods, where the ground was furrowed, were so hard that the only available steam roller made no impression on them, and they had to be broken by hand with picks.

[5] Greeks disliked water-drinkers. "They say," says Demosthenes, "that being a water-drinker, I am naturally a cross-grained and ungenial fellow" (Demosthenes, *Philip*, ii. 30, 73; cf. Aristophanes, *Knights*, ii, 89, 345). But they did not drink their wine neat. The proportion of water to wine varied, and might be decided by the president of the company, who also prescribed the toasts. The normal mixture in the fifth century seems to have been three of water to two of wine (Aristophanes, *Knights*, 1187). The proportion five to two is also mentioned as usual (Athenæus, x. 426).

e.g. "When you hear the voice of the crane who cries year by year from the clouds above [i.e. in the middle of October] mark it well, for she gives the signal for ploughing and shows that the season of rainy winter is near"; or "When the house-carrier climbs up the plants from the earth to escape the Pleiades [middle of May], then is the time to whet your sickles." The house-carrier is, of course, the snail. Hesiod, like other rustics, has queer old-fashioned names for beasts. The ant is "the Wise One," the cuttlefish "the Boneless One," the burglar "the Man who sleeps by Day." Some things, of course, it is unlucky to mention by name—tombstones, for instance. "Do not let a boy of twelve years sit on that which may not be moved, for that is bad and makes a man unmanly."[1] He knows, too, all about lucky and unlucky days, and he is a mine of rustic lore. The fourth is the lucky day to be married. The fifth is a very unlucky day. Men born on the twentieth of the month in daylight are very wise. The nineteenth is a lucky birthday for boys, and the fourth for girls. Never put the ladle on the mixing-bowl at a wine-party, for malignant

FLOCKS COMING INTO MAUDIA IN THE MIDDLE OF THE DAY.



THERA—THRESHING FLOOR.

[1] The superstitious man in Theophrastus will not tread on a tombstone (Theophrastus, *Characters*, xxviii).

ill-luck is attached to that; nor when building a house leave it rough-hewn, for a cawing crow might settle on it and croak.

The seasons in different parts of Greece vary, of course, with latitude and altitude; but normally there is no rain from the end of March to October. The spring is wonderful. The hot sun on the ground soaked by the winter rains produces a mass of wild flowers, and the whole ground is carpeted with living colour.

> "All fragrant with woodbine and peaceful content and the leaves which the lime blossoms fling,
> When the plane whispers love to the elm in the grove in the beautiful season of spring."[1]

Harvest, as we have seen, in most parts of Greece is reaped in May or early June. When the grain has been threshed and winnowed, there is nothing more to be done in the fields until the autumn. Normally, in the Eastern Mediterranean there are two rainy spells, what the Bible calls the former and the latter rains. The former rain, the light rains of autumn, soften the ground. Now is the time for the farmer to go up the mountain side and cut himself timber for a plough. Hesiod advises making two, one being all of a piece, in case of accidents. Now, too, is the time to break up the fallow land; for Greek antiquity did not know rotation of crops, and land cropped one year lay idle the next. The true ploughing season came later in the period of the latter rains. December was the best time, though there were those who affected the late ploughing in March, which in some years produced good results. The sower went behind the plough, scattering the seed, and Hesiod recommends a man to follow him with a mattock to turn the soil over the seed before the birds get at it.[2]

The tools and methods of agriculture in Hesiod's time were very much those in use to-day in modern Greece. The plough is still little more than an iron-shod stake which scratches the surface of the light and stony soil. Deep ploughing would, in fact, be impossible among its boulders.

Corn was reaped with a sickle in May, and then taken to the threshing-floor, a paved, circular space set upon a high place which catches the summer breeze. The grain is threshed either by being trodden out by beasts or ground out by a wooden sledge. This is an oblong frame of wood studded on the bottom with pieces of flint. The driver stands upon it to press it down, and drives round and round over the corn.[3] When this has been shaken out of the ears, it is winnowed by throwing it with a long-handled shovel into the air against the wind. The heavier grain then falls in one heap, while the light chaff is carried further down-wind into another. For this process a gentle, steady breeze gives ideal conditions. "It is not then the same wind which blows on the threshing-floor as that which fills the sails."[4]

[1] Aristophanes, *Clouds*, 1007 (trans. Rogers).

[2] See British Museum Guide to the Exhibition illustrating Greek and Roman Life, fig. 216, p. 208. A well-known black figured vase by Nicosthenes depicts ploughing and sowing (see *Companion to Greek Studies*, p. 539).

[3] I photographed a Cretan sledge of this type in 1916. On the other hand, similar flints for setting in a threshing sledge were found in one of the prehistoric cities at Phylakopi, Melos. This method has therefore a long continuous history.

[4] A. W. Mair's translation of Hesiod (Clarendon Press, 1908) may be recommended to those who are unable to read the original. The British Museum Guide Books, which give the reader certainly the most wonderful value in archæological publication, containing as they do abundant illustrations, and costing 1*s.* or 1*s.* 6*d.*, are too little known and used. For students of Greek and Roman history the *Guide to the Department of Greek and Roman Antiquities* and that above quoted are invaluable. The Guide Books to the Stone, Iron, and Bronze Age collections, and the excellent handbook to the Ethnographical Section, can also be warmly recommended.

(*To be continued*)

The Future of the Airship in Commercial Transport

By Major George Whale (late R.A.F.)

A SOMEWHAT pessimistic tone is prevailing, at present, concerning the utility of aircraft for commercial purposes. It is true that the development of aerial transport companies has not been as rapid as aeronautical experts hoped would be the case with the coming of peace, but the reason for this is not far to seek. Europe, if not the whole world, is suffering from a state bordering on bankruptcy, with the result that money for scientific research and for the necessary experiments incidental to civil aviation is only forthcoming to a limited extent.

When this is considered, it must be conceded that considerable progress has been made in establishing passenger and mail-carrying services by aeroplane both in this country and on the Continent, as well as in America.

Most unfortunately, the form of aircraft which appears to hold out by far the greatest possibilities, namely the airship, has been neglected entirely as far as Great Britain is concerned.

The successful crossing of the Atlantic by the rigid airship R34 proved that such a flight could be undertaken without undue risk, and it might have been

imagined that a great stimulus to airship transport would have accrued.

It is admitted that the saving of time effected by aeroplane flights is largely neutralised by the fact that passengers and cargo have to be landed on the outskirts of cities, and from thence taken to their destination by existing means of transport. This argument, although holding good for flights over a comparatively speaking short distance of ground, cannot be cited against the airship when maintaining services across the oceans and continents, which will shorten the duration of journeys by several days.

In addition, it is possible to build an airship capable of carrying passengers and goods in great quantity without any radical alteration in design, a state impossible of attainment with the aeroplane as at present constructed. This happy position seems to be the crux of the whole question, as it is only the carrying of goods in bulk or passengers in large numbers which will render any aerial transport company a profitable enterprise.

Official figures have been published to show that an airship service can be maintained between this country and India by using airships of the type and capacity of R38, a ship nearing completion in this country which has been sold to the Americans. This ship has a capacity of only $2\frac{3}{4}$ million cubic feet, and yet could carry over fifty passengers together with mails. The figures, which have been worked out in addition for services to other parts of the globe, give approximate times of transit of 2 days to Egypt, $4\frac{1}{2}$ days to India, 6 days to South Africa, and $9\frac{1}{2}$ days to Australia. Moreover, the suggested passenger fares are not greatly in excess of those demanded by the steamship companies to-day. This undertaking is estimated to produce a profit of 15 per cent., and proves that a return may be expected on capital outlay with the airship as it exists to-day.

Calculations have been made, also, for operating airship services using ships of $3\frac{1}{2}$ million cubic feet capacity. The constructional sheds in this country are large enough to accommodate such vessels. An estimated disposable lift of 68 tons will be attained, of which some 15 tons will be available for passengers and cargo. New York could be reached in $2\frac{1}{2}$ days from London, while it is estimated that the time taken to make the journey between England and Australia would be 7 days, allowing twelve hours for refuelling at Cairo and Colombo.

These figures are in themselves sufficiently astonishing as showing that there is hardly a city in the world which could not be reached from London in less than a fortnight, while the saving in time to business men, both for personal travel and conveyance of letters, must be manifestly of the greatest importance.

There is, practically speaking, no limit whatever to the carrying powers of the airship, as this is determined by merely increasing the size, and the lift is proportional to its cubic capacity. For example, an airship of the volume of 10 million cubic feet would have five times the lift of the airship of 2 million cubic feet, but the length of the former would be only 1·7 times greater.[1]

A ship of this size would have some 200 tons lift available for fuel and freight, and would possess sufficient endurance to voyage round the world without refuelling.

The Germans are aware of the unbounded possibilities open to the airship, and are at the moment under negotiations with the Americans to finance a company to exploit a service with large airships between New York and Berlin. By the close of the war we had reached the position of the leading Power in the air, and it is to be hoped that, when it is realised that the value of airships is appreciated in foreign countries, we shall take every step possible to retain that supremacy.

An Up-to-date Meteorological Equipment—I[2]

By Donald W. Horner, F.R.A.S., F.R.Met. Soc.

Rain-gauges

In a short series of articles, it is intended to deal with up-to-date meteorological instruments, to interest readers generally in meteorology.

In recent years the Royal Meteorological Society has ceased to collect observations, but the Meteorological Office, with its newly acquired branch the British Rainfall Organisation, both require fresh voluntary observers in various parts of Great Britain and Ireland. Rainfall observers are required by the last-named institution, and those wishing to undertake the work are invited to send a post-card to the Superintendent at 62 Camden Square, London, N.W.1, who will send full particulars of how the work should be done, and where rainfall-stations are required most.

It is only by an intelligent comprehension of the geographical distribution of rainfall that eventually we may be made to utilise the vast quantities of water now allowed to run to waste annually.

Rainfall observations are therefore considered of such importance that we shall first of all consider the rain-gauge.

[1] Since volumes of similar figures are proportional to the cubes of their lengths, and the cube root of 5 is approximately 1·7.

[2] All illustrations except Fig. 4 are from blocks lent by Messrs. Negretti & Zambra, of London.

Rainfall is not only influenced by geographical position, but also by the height and proximity of mountains and of the sea, in some cases even of hills and forests. If, therefore, we have a neighbour living

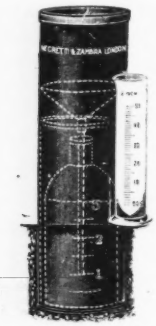


FIG. 1.—SNOWDON RAIN-GAUGE AND MEASURE-GLASS.

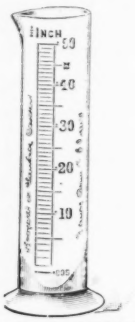


FIG. 2.—CAMDEN MEASURE-GLASS.

on a hill near us who keeps a record of the rainfall, that is not a sufficient reason for our omitting measuring the rainfall by a rain-gauge in our own back garden. In partial storms it is quite possible that we record more than an inch of rain, and our neighbour's gauge remains perfectly dry. The opposite may also be the case.

The instruments described in these articles will be those used at—

(1) Stations of the First Order, or Self-recording Observatories.
(2) Stations of the Second Order, or Normal Climatological Stations.
(3) Stations of the Third Order, or Auxiliary Climatological Stations.
(4) Telegraphic Reporting Stations.
(5) Anemograph Stations.

The descriptions, however, will be given not in the order in which they are used at these stations, but in the order of simplicity in use, commencing with the simplest. Each instrument will be allocated its proper position at each station in a summary in the concluding article.

The best and most usual pattern of rain-gauge in use to-day is the "Snowdon," a gauge having a funnel 5 inches (12·7 centimetres) in diameter.

The funnel has a brass rim at the top, the inner edge of which is cut sharply to the diameter mentioned. The funnel itself is 4 inches in depth.[1]

The reason for adopting this gauge with a deep funnel is that snow cannot blow or hail jump out of it after it has been caught. In old-fashioned rain-gauges with shallow funnels, relatively a large amount of snow was lost during high winds. In consequence the amount of precipitation appeared too little when measured in these gauges.

A second reliable gauge is the Meteorological Office pattern rain-gauge. The diameter of the funnel of this one is 8 inches (20·3 centimetres), and except in size is similar in every way to the Snowdon. Observations made with either of these instruments are accepted as equally trustworthy by the Meteorological Office and the British Rainfall Organisation. In purchasing rain-gauges, a prospective buyer will find it best to get a copper apparatus. A copper rain-gauge costs more initially, but it lasts practically a life-time, and it does not require periodical repainting as the cheaper ones do. Secondly, he should decide whether he intends to measure the amount of precipitation in inches or in millimetres. It makes no difference in which units the measurements are made provided one unit is kept to throughout. An inch is equal to 25·4 millimetres, and a millimetre is 0·03937 inch. For convenience, the millimetre may be considered equal to 0·04 inch, but it is clear that if this value be used for converting from one unit into the other, small errors arise, while if the correct value be used, it involves quite a lot of arithmetic. It is best, therefore, to keep to one unit throughout.

If the rainfall be measured in inches, a Camden measure-glass is necessary for the estimation of small amounts of rainfall. These glasses hold half an inch and are graduated in tenths and hundredths. There are measure-glasses also graduated in millimetres and tenths. They hold 10 millimetres (approximately $\frac{2}{5}$ inch).

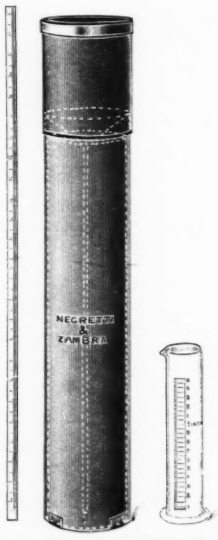


FIG. 3.—BRADFORD RAIN-GAUGE.

[1] Experiments made recently by Mr. W. H. Dines at Benson, Oxford, seem to suggest that the ideal rim should have a slope inside as well as outside, the cross-section being like the gable-end of a house.—*Meteorological Magazine*, June 1920

When it is said that an inch of rain has fallen, it is meant that sufficient water has fallen to fill to overflowing a vessel 1 inch long, 1 inch wide, and 1 inch deep—that is, a cubic inch of water has fallen on every square inch of land. Since an acre contains 6,272,640 square inches, an inch of rain on this area means that 101 tons of water have fallen. For the amount fallen is 6,272,640 cubic inches; 1728 cubic inches equal one cubic foot; a cubic foot of water weighs 62¼ lb.; and so, by calculation, we arrive at the above result.

Having decided the kind of gauge to use, our next problem is to select a site as free as possible from such obstructions as buildings, trees, and walls. A good plan is to place the instrument as far away from the obstacle as the obstacle is high. The late Dr. R. H. Scott, formerly Secretary and Director of the Meteorological Office, recommended that "the angle subtended in each azimuth by the nearest obstacle . . . should not exceed 30 degrees, and the true bearing of the obstacle from the gauge should be carefully measured and noted in the register." In plain language, the Meteorological Office recommends that the gauge be twice the distance from the obstacle as the height of the object in question, though it must be admitted that this is not always possible in small gardens. In a desire to avoid obstruction, we must avoid the other extreme. The site must not be too exposed, nor should it be on sloping ground.

The rain-gauge is best fixed into the ground by fitting its base accurately into a hole lined with cement-concrete. Meteorological Office gauges are frequently made with splayed bases, and if these are firmly embedded in cement, it is quite impossible for them to blow over.

All gauges should have a capacity of 4 inches at least, for it is possible that rain sufficient to fill a gauge of this size may fall in the British Isles in 24 hours. Indeed, falls of as much as 9 and 10 inches have been known to take place in this country.

We will now suppose that a fall of rain has taken place. We visit the gauge, which, we will assume, is marked in inches, at 9 a.m. G.M.T.,[1] the usual hour for making such observations. We remove the funnel, laying it carefully aside, take out the inner can or bottle, as the case may be, and pour the contents into the Camden measure-glass. Each mark on the glass, except the bottom one, indicates one hundredth of an inch. The bottom one indicates half a hundredth. When small amounts of rain have fallen, this bottom mark is of importance, because if the water stands above it, the amount is recorded as 0·01 inch and the day is known as a "rain day." If the water does not reach the mark, the record becomes "trace."

We will assume, however, that the fall has been a heavy one, and that the water has reached the twenty-seventh mark. This is recorded as 0·27 (each mark being a hundredth of an inch). If we find there is more water in the gauge than fills the measure-glass (capacity 0·50 inch), we proceed to fill it accurately as many times as it is possible, and measure the fraction over also. Thus, if there is sufficient water to fill the measure-glass three times and to fill it for the fourth time to the mark 0·23, the recorded fall will be $3 \times 0{\cdot}50 + 0{\cdot}23$, i.e. 1·73 inches. A similar procedure with a measure-glass graduated in millimetres and tenths enables a record to be made in that case also.

When snow falls instead of rain, the method of measurement is modified slightly in one of two ways. The first method is to remove the funnel of the gauge, taking care not to lose any of the snow retained in it,

FIG. 4.—LIVINGSTONE PORTABLE RAIN-GAUGE.

and to take it and the bottle or can near to a fire, so that the whole of the snow may be melted. The water is then measured in the usual way. The second way is to measure say ½ inch of warm water in the measure-glass, and pour it over the snow in the funnel so that it melts and runs down the tube into the bottle below. The actual rainfall is then the whole amount measured less the amount added to melt the snow. Hail may be dealt with in the same way.

When positions are chosen for rain-gauges where they cannot be visited daily, it is necessary to employ a mountain rain-gauge such as the Bradford. The Bradford is a Snowdon gauge modified to suit the purpose for which it is intended. Its funnel is 5 inches in diameter, but the inner can is made to contain from 12 to 30 inches according to the rainfall of the district in which the gauge is to be used. This gauge measures, of course, the monthly rainfall, if the readings are made once a month (usually at 9 a.m. on the first of the month). Before measuring the quantity of water in the usual way with the measure-glass, the

[1] Greenwich Mean Time. In official observations, time is reckoned from midnight in 24-hour periods; 9 a.m. being 9 hours, and 9 p.m. 21 hours, and so on. "Summer time" is ignored.

approximate amount of water is ascertained by means of a graduated dip-rod. This checks the more accurate determination of the amount by means of the measure-glass, and prevents any uncertainty as to the number of times it has had to be successively filled.

For explorers and travellers there is a portable rain-gauge. This has a funnel of diameter 3 inches, and every part is small in proportion for the sake of portability. A good example of this type is the Livingstone Portable Rain-gauge made on the same lines as that originally supplied to Dr. Livingstone for use in his African travels.[1]

Before concluding this section, it may be well to state briefly how the markings on the measure-glasses are calculated. Since "an inch of rain" means a cubic inch of water on a square inch of surface, we proceed to calculate as follows. Let our rain-gauge have a diameter of 8 inches. If it be filled with water to the height of 1 inch, the volume of water in it is $\pi r^2 h$ (r = radius; h = height), i.e. $\pi \times 4^2 \times 1 = 16\pi = 50{\cdot}265$ cubic inches. Now, when this amount of water is poured into a Camden measure-glass, the measure-glass has to record 1 inch. Since the Camden when filled holds $\frac{1}{2}$ inch only, its volume must be 25·132 cubic inches. If R be its radius and H the height that records $\frac{1}{2}$ inch of rain, $\pi R^2 H$ must equal 25·132 cubic inches. R is usually $1\frac{1}{4}$ inches, $\therefore H = 5{\cdot}12$ inches. A measure-glass of $2\frac{1}{2}$ inches diameter, when filled to this height with water from an 8-inch gauge, "records $\frac{1}{2}$ inch of rain." It is an easy matter now to calculate the heights which record different hundredths of an inch.

NOTE.—Further information on rain-gauges may be obtained in *The Principles of Aerography*, by Alexander McAdie (Harrap, 21s. net); *Meteorology for All*, by D. W. Horner (Witherby, 6s. net); and *Meteorology: Practical and Applied*, by Sir John Moore (Rebman, 10s. 6d. net).

Lord Lister

APRIL 5, 1827—FEBRUARY 10, 1912

The Discoverer of the Antiseptic System of Surgery

By Edward Cahen, A.R.C.S., F.I.C.

THE rise of industrialism in the nineteenth century, with the consequent migration of the artisans from the country to the factories in the great towns, led to overcrowding in the hospitals; partly on account of the decreased vitality and power of resistance to disease, and partly because of the increased number of accidents inseparable from such an existence. "Disease is the shadow of death that clouds the life of man. When Lister was born this shadow was probably deeper than at any other time; so deep, in fact, that it threatened the very existence of industrial populations"[2] for the reasons just given. It was to dispel this shadow that Lister was born in the spring of 1827, of Quaker parents, who were then residing at West Ham. His father was a scientist and a Fellow of the Royal Society, and had made the first achromatic microscope, and it was from him that young Lister learnt to appreciate this instrument of research, which led to such important results in his later work.

He received his early education at a Quaker school, and then passed to University College, Gower Street, in 1844. Medical training was then just beginning to emerge from the dark ages of body-snatching and apprenticeship. In this school, which has turned out so many distinguished men, he came into contact with Thomas Graham, from whom he received a good grounding in chemistry, and William Sharpey, the Professor of Physiology, who awakened in him a keen desire for research. In 1852 he published, with some very fine drawings he had made in illustration, his first piece of research, which dealt with the mechanism of the iris of the eye. In time he became dresser and later house surgeon to Eric Erichson, the author of one of the most famous textbooks on surgery in the English language. In this position he came across "hospital gangrene" and all its horrors for the first time. The general practice of the day was to burn away the affected parts with caustic, but the suffering and toll of death remained unabated; there was a very generally accepted view that it was the oxygen of the air which burnt up the tissues and gave rise to the inflammatory conditions observed. Lister discovered the true reason while examining the diseased tissues with his microscope. He concluded that the cause of the trouble might be "in the form of some kind of fungus."

In the same year that his first research was published he was sent with a letter of introduction to James Syme, the Professor of Clinical Surgery in Edinburgh, and the greatest surgeon of his day. This visit resulted in his remaining for twenty-five years in the North, and when he returned to London it was with a world-wide reputation, and to convert his native city to his system of antiseptic surgery. He held various posts under Syme in the Edinburgh Infirmary, and four years later married Syme's daughter; thus it came to pass that he gained from both father and father-in-law the knowledge by which he was able to revolutionise the art of surgery.

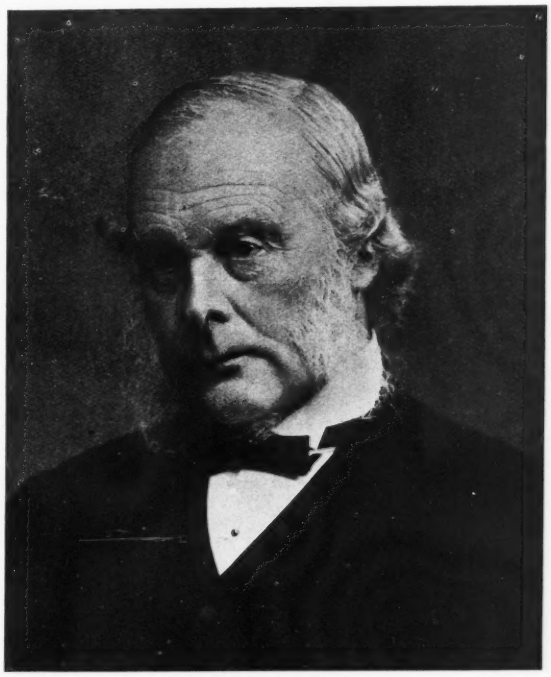
There he studied the reaction of living tissue to attack, and came to the conclusion which was the basis

[1] The illustration of this instrument is lent by Messrs. C. F. Casella, London.

[2] G. T. Wrench, M.D.

of his great discovery, that the lack of vitality after an injury made the wounded flesh a prey to attack from some agent as yet unknown.

In 1860 he was appointed Professor of Clinical Surgery in the University of Glasgow, but it was not till a year later that he became surgeon to the Infirmary in that city. Here again he came into contact with those terrible conditions pertaining to public hospitals, their fetid odour, the look of suffering, and the fear of death. It was truly said at the time that the victim of a street accident stood a better chance of recovery outside these "houses of death" than in their wards. The discovery of the anæsthetic properties of chloroform by Sir James Simpson in 1847 had in a sense made matters worse, for it had led to more operations, and consequently more deaths from hospital gangrene. Only about 60 per cent. of the patients of those days ever recovered from an operation. The Glasgow wards were no better than the others, and although Lister introduced both air and cleanliness into them, the death roll was not appreciably diminished. Accordingly he proceeded to search the literature of three lands, and in 1865 came across Pasteur's work, and the great discovery of the existence of microbes in the dust of the air, with which readers of DISCOVERY [1] will be familiar. He immediately connected the results obtained by Pasteur with his own early work on the paralysis of the tissues when injured. He concluded that the tissues, when their protective vitality was temporarily wanting, became the prey of the micro-organisms just as though they were dead and in the proper condition for putrefaction to set in. This explained why it was putrefaction only began in cases of compound fracture where the skin was broken, and not in cases of simple fracture where the skin was not cut. Thus it came about that Lister, through his use of the microscope, was the only one who, on hearing of Pasteur's discovery, was able to grasp its full meaning. He had a perfectly clear vision of the microbes attacking the apparently dead tissues, which through their temporary lack of vitality were unable to resist. The problem was now a simple one to be solved by simple methods. Kill the microbe and allow the tissues to regain their vitality and power of resistance. The wounds, whether accidental or the result of surgical interference, would then heal up quickly. This is what Lister set out to do. His attention had been attracted to an experiment made by the City authorities at Carlisle in destroying the odour of their sewage by means of carbolic acid. It struck him that this might be just the agent for his purpose. The carbolic acid of that day, it must be noted, was very impure, being full of tarry matter and very insoluble in water. The first experiment was made in 1866 on a small boy, who was brought in from a street accident with a compound fracture of his leg. Cleaned and dressed with carbolic, the wound healed, and the boy was soon able to walk again. Having thus found out how to deal with such cases, and having successfully treated many of them, Lister passed on to the consideration of cases of chronic abscess, which more often than not proved fatal on operation. Here again he succeeded, where others had failed, by his firm belief in the germ theory, and by his careful exclusion of all contamination from the wound by his carbolic dressings. It was an age of controversy; no one could understand why it was that the mortality in hospital was so much greater than in the rural districts; there was a discussion as to the best form of ligature to employ. Lister wisely kept aloof from all controversy, and set to work to find out these things for himself by means of numerous experiments. He reduced the mortality in his wards at Glasgow by the simple expedient of washing everything—the wound, the hands of the operator, and the instruments used—in carbolic solution. He found that catgut sterilised in carbolic acid was by far the best ligature to use, but for twelve years he kept an open mind regarding the merits of the various catguts obtainable. He even paid visits to the factories where they were produced. Finally he fixed upon the one in use to this day.



LORD LISTER.
By kind permission of Messrs. Elliott & Fry.

[1] DISCOVERY, November 1920, p. 330.

It was not till 1870, soon after he had gone to Edinburgh to fill the position of his father-in-law (who had retired through illness), that he finally decided to publish his antiseptic system, thinking that it should no longer be withheld from suffering humanity; as he himself expressed it: "The antiseptic system has now been in operation sufficiently long to enable us to form a fair estimate of its influence upon the salubrity of a hospital. Its effects upon the wards lately under my care in the Glasgow Infirmary were in the highest degree beneficial, converting them from some of the most unhealthy in the kingdom into models of healthiness. The interests of the public demand that this striking change should be generally known."

Like all innovators, Lister was immediately attacked from all sides, and more especially by the surgeons of his own land. It was seven years before the surgeons of London finally capitulated, and only then when he came down from the North personally to demonstrate his system to the unbelievers. The controversy centres round the germ theory of Pasteur, and Lister met with just the same trouble from his colleagues in England as the great Frenchman was encountering in France. He even went so far as to repeat some of Pasteur's experiments with improvements of his own, and in every case obtained results which confirmed the conclusions arrived at by Pasteur regarding the origin of putrefaction and disease. As is so often the case, the recognition which was denied hm by his own countrymen was accorded him by the surgeons of foreign countries, and more especially by those of Germany and Denmark. In 1875 the Congress of German Surgeons met in Berlin, and sent him an invitation to visit Germany, an invitation which he accepted in the summer of that year, making a triumphal progress from town to town.

The hostility of the London surgeons to the new system was galling to Lister, not because of any feeling of personal slight, but because he did not like to think of all the suffering still being endured by patients from whom the advantages of the new system were being wilfully withheld. It was on this account that in 1877 he left Edinburgh and accepted a much inferior post as Professor of Clinical Surgery at King's College, London. Lister came South to fight for his system, and it was not long before the results he obtained made further fight unnecessary. The London surgeons gave in; the victory was gained finally; but the triumph did not come till two years later when he was acclaimed by the International Congress of Medical Science in Amsterdam.

Lister was a man of extreme simplicity, and possessed of a serenity that was no doubt inherited from his Quaker ancestors. As a surgeon he was bold with the boldness born of certainty. His outlook on life was philosophical, and his system of antiseptic surgery was the outcome of his view of life. It was only after countless experiments that he finally fixed upon the most suitable dressing to ensure the best results. That dressing, a mercury-zinc-cyanide gauze, is still in use to-day.

NOTE.—The reader will find *Lord Lister, His Life and Work*, by G. T. Wrench, M.D. (Lond.) (Fisher Unwin, 1913), most interesting and readable.

Books of the Month[1]

The following is our monthly selection of books which we commend to the notice of our readers.

And Even Now. By MAX BEERBOHM. (Heinemann, 7*s.* 6*d.*)
Twenty recent essays delightfully written.

Winsome Winnie and other Nonsense Novels. By STEPHEN LEACOCK. (John Lane, 5*s.*)
Excellent skits on the most usual plots of novels.

In the Mountains. ANONYMOUS. (Macmillan, 7*s.* 6*d.*)

Essays on Books. By A. CLUTTON-BROCK. (Methuen, 6*s.*)

The Art of Letters. By ROBERT LYND. (Fisher Unwin, 15*s.*)

A History of Scotland from the Roman Evacuation to the Disruption. By PROF. C. S. TERRY. (Cambridge University Press, 20*s.*)

English Wayfaring Life in the Middle Ages (XIVth Century). By J. J. JUSSERAND. Translated by LUCY TOULMIN SMITH. (Fisher Unwin, 25*s.*)

The World of Sound. By PROF. SIR WILLIAM BRAGG, K.B.E., F.R.S. (Geo. Bell, 6*s.*)
The Christmas lectures of last year at the Royal Institution.

Instinct and the Unconscious. A contribution to a Biological Theory of the Psycho-Neuroses. By W. H. R. RIVERS, M.D., D.Sc., F.R.S. (Cambridge University Press, 16*s.*)

Secrets of Earth and Sea. By SIR RAY LANKESTER, K.C.B., F.R.S. (Methuen, 8*s.* 6*d.*)
A delightful book of non-technical science.

The Place Names of Northumberland and Durham. By PROF. ALLEN MAWER. (Cambridge University Press, 20*s.*)

An important volume of the Cambridge Archæological and Ethnological Series dealing with the origins of the place-names of two counties.

[1] Short accounts of some of these and of other books will be given next month.